Basis Weight Unstability Evaluation & Stabilization Using Process Upgradation

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ABSTRACT

In many of the cases, the basis weight keeps on changing frequently almost randomly, and even after a lot of efforts, papermakers do not get satisfactory results. This work indicates how an insight into process and profile unstability can be used to minimize basis weight variations. In this case study, the case of a kraft paper mill has been considered, and indicated how the basis weight variations have reduced.

INTRODUCTION

Basis weight variation is the most common problem in the paper mills. However best you work, the profile is never perfect, and a good papermaker is never satisfied with the results. The hunger for a stable, perfect profile makes papermakers use different techniques, including consistency and basis weight controllers, scanners, DCS & QCS systems etc. The mills, which cannot afford to install these systems, feel themselves helpless.

Still, in many of the cases, mills fail to achieve desired results even with good DCS & QCS systems. The use of process analysis and optimization has been found successful for implementation in a small paper mill.

Concept

The basis weight variations do exist in both machine and cross directions, in different frequency and amplitude levels due to numerous reasons. Here are a few for instance-

1. Rotation of pressure screen results in GSM fluctuation at a frequency level of its rotational speed multiplied by number of vanes in the impeller.
2. Rotations of fan pump results in GSM fluctuation at a frequency level of its rotational speed multiplied by number of vanes in the impeller.
3. Tapered or straight linear centricleaner headers (both inlet & accept) dampen the sudden change of basis weight to a slowly changing one. This becomes a source for cross directional profile unstability.

There are many similar reasons for GSM variations. Unfortunately, normally available consistency and flow control loops even supervised by DCS & QCS systems fail to compensate for high frequency pulsations.

Approach

The approach was to measure and analyze MD profiles at different CD positions. The measurement was so designed as top give the effect of different frequency pulses being generated from different sources. To begin with, profiles of several consecutive rolls were noted and the profile unstability was evaluated. A higher value of the same say beyond 0.5gsm means the profile may be considered as unstable.

Getting checked the unstability, one roll from the paper machine was selected for which it was believed that there was no intentional basis weight change, and the operators were of the opinion that this is one of the best rolls. During production of this roll, machine chest consistency was kept constant, pre-machine chest level kept initially full to avoid any furnish freeness or other drainage properties variation, and ensured that there was no fan pump flow variation etc, as the plant was running on DG set and hence there was no voltage or frequency fluctuation in the electrical supply.

Reels were cut from this roll, and from the middle of each reel, samples were collected after a predetermined machine direction distance. The distance chosen was such that for nearly one and a half minute of production, some 80-100 samples may be taken. In this way, the target was basically to get actual basis weight value after almost every second.

Thus obtained MD basis weight profile was plotted using Microsoft Excel Spreadsheets, and used for analysis of data.

Roll No.	#1	#2	#3	#4	#5	#6	#7	#8	#9	Var	Avg.
1	115.0	115.0	119.0	119.0	120.0	119.0	120.0	120.0	119.0	*5.0*	118.4
2	112.0	112.0	116.0	116.0	119.0	118.0	115.0	116.0	116.0	*7.0*	115.6
3	120.0	122.0	121.0	120.0	122.0	120.0	119.0	120.0	123.0	*4.0*	120.8
4	117.0	119.0	114.0	117.0	115.0	116.0	118.0	118.0	119.0	*5.0*	117.0
5	112.0	116.0	114.0	118.0	112.0	114.0	114.0	115.0	116.0	*6.0*	114.6
6	116.0	118.0	114.0	115.0	112.0	116.0	118.0	120.0	118.0	*8.0*	116.3
7	118.0	118.0	114.0	114.0	115.0	120.0	120.0	120.0	117.0	*6.0*	117.3
8	120.0	122.0	118.0	119.0	120.0	120.0	119.0	119.0	120.0	*4.0*	119.7
9	122.0	123.0	123.0	121.0	120.0	122.0	121.0	122.0	122.0	*3.0*	121.8
10	122.0	120.0	119.0	122.0	119.0	123.0	121.0	121.0	122.0	*4.0*	121.0
Min	**112.0**	**112.0**	**114.0**	**114.0**	**112.0**	**114.0**	**114.0**	**115.0**	**116.0**	**3.0**	**114.6**
Max	**122.0**	**123.0**	**123.0**	**122.0**	**122.0**	**123.0**	**121.0**	**122.0**	**123.0**	**8.0**	**121.8**
Avg.	**117.40**	**118.50**	**117.20**	**118.10**	**117.40**	**118.80**	**118.50**	**119.10**	**119.20**	**5.20**	**118.2**
Range	**10**	**11**	**9**	**8**	**10**	**9**	**7**	**7**	**7**	**5**	**7.2**

Table 1: Basis Data Obtained from the Plant.

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Available Data

The following data were obtained from the plant-

1. Machine Speed, 230mpm
2. Head Box Consistency, 1.2%
3. Back Water Consistency, 2300ppm
4. Pressure Screen 450RPM
5. Head Box Holey Roll 15/22RPM
6. Primary Centricleaner Inlet Pressure, 3.5bar
7. Pipe Size fan pump suction 10"NB
8. Basis weight valve opening 50% nominal
9. Target basis weight 120gsm

Profiles of Consecutive Rolls

The complete analysis used a lot of data, which is difficult to present in this article. That is why, only a fraction of actual data taken from several rolls is presented, in order to illustrate the technique of data analysis.

Table 1 shows data obtained from the plant for 120gsm kraft paper. It can be easily seen that the average gsm is varying between 114.6gsm to 121.8gsm. In the detailed analysis this variation was found to be 114.0 to 128.2gsm. All data are not given in this paper due to space constraints.

In the next sheet, average of each profile has been subtracted from individual profile value, in order to get absolute profile. An absolute profile indicates how much a particular position is overweight or underweight. For example, for the first roll, the actual profile is as shown of left

#1	#2	#3	#4	#5	#6	#7	#8	#9	Var.	Avg.
115.0	115.0	119.0	119.0	120.0	119.0	120.0	120.0	119.0	5.0	118.4

For this roll, subtracting 118.4 from each value of the profile, we get the absolute profile as under-

-3.4	-3.4	0.6	0.6	1.6	0.6	1.6	1.6	0.6

In this way, the absolute profile for the above rolls has been given in Table-2.

RollNo.	#1	#2	#3	#4	#5	#6	#7	#8	#9	Var
1	-3.4	-3.4	0.6	0.6	1.6	0.6	1.6	1.6	0.6	5.0
2	-3.6	-3.6	0.4	0.4	3.4	2.4	-0.6	0.4	0.4	7.0
3	-0.8	1.2	0.2	-0.8	1.2	-0.8	-1.8	-0.8	2.2	4.0
4	0.0	2.0	-3.0	0.0	-2.0	-1.0	1.0	1.0	2.0	5.0
5	-2.6	1.4	-0.6	3.4	-2.6	-0.6	-0.6	0.4	1.4	6.0
6	-0.3	1.7	-2.3	-1.3	-4.3	-0.3	1.7	3.7	1.7	8.0
7	0.7	0.7	-3.3	-3.3	-2.3	2.7	2.7	2.7	-0.3	6.0
8	0.3	2.3	-1.7	-0.7	0.3	0.3	-0.7	-0.7	0.3	4.0
9	0.2	1.2	1.2	-0.8	-1.8	0.2	-0.8	0.2	0.2	3.0
10	1.0	-1.0	-2.0	1.0	-2.0	2.0	0.0	0.0	1.0	4.0
Min	-3.6	-3.6	-3.3	-3.3	-4.3	-1.0	-1.8	-0.8	-0.3	3.0
Max	1.0	2.3	1.2	3.4	3.4	2.7	2.7	3.7	2.2	8.0
Avg.	-0.84	0.26	-1.04	-0.14	-0.84	0.56	0.26	0.86	0.96	2.0
Range	4.56	5.89	4.56	6.78	7.78	3.67	4.44	4.44	2.56	5.00

Table-2: Absolute Profile computed for given rolls.

RollNo.	#1	#2	#3	#4	#5	#6	#7	#8	#9	Var	Avg.
1	0.1	0.1	0.1	0.1	1.9	1.9	**2.1**	1.1	0.1	2.0	0.8
2	**2.8**	**4.8**	0.2	1.2	**2.2**	**3.2**	1.2	1.2	1.8	4.6	2.1
3	0.8	0.8	**3.2**	0.8	**3.2**	0.2	**2.8**	1.8	0.2	3.0	1.5
4	**2.6**	0.6	**2.4**	**3.4**	0.6	0.4	1.6	0.6	0.6	3.0	1.4
5	**2.2**	0.2	1.8	**4.8**	1.8	0.2	**2.2**	**3.2**	0.2	4.6	1.9
6	1.0	1.0	1.0	**2.0**	**2.0**	**3.0**	1.0	1.0	**2.0**	2.0	1.6
7	0.3	1.7	1.7	**2.7**	**2.7**	**2.3**	**3.3**	**3.3**	0.7	3.0	2.1
8	0.1	1.1	**2.9**	0.1	**2.1**	0.1	0.1	0.9	0.1	2.8	0.8
9	0.8	**2.2**	**3.2**	1.8	0.2	1.8	0.8	0.2	0.8	3.0	1.3
Min	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.1	2.0	0.8
Max	2.8	4.8	3.2	4.8	3.2	3.2	3.3	3.3	2.0	4.6	2.1
Avg.	**1.19**	**1.38**	**1.84**	**1.88**	**1.85**	**1.47**	**1.68**	**1.48**	**0.72**	1.2	1.5
Range	2.67	4.67	3.11	4.67	3.00	3.11	3.22	3.11	1.89	2.56	1.23

Table-3: Unstability for the given rolls.

Now, from the absolute profiles, if we subtract individual values of one profile from that of the next profile, and remove the minus (-) sign from the negative values, we get unstability for the two rolls. In short, if some typical value in a profile is say 1.0 gsm higher than that of average, and becomes 1.0gsm lower in the next profile, there exists an unstability of 2.0. In Table-3, unstability is given.

It must be noted that the above calculations were done using Microsoft Excel, and due to rounding errors, some values in unstability table may seem deviated by 0.1gsm. Anyway, as clear from Table-3, the average unstability is 1.5gsm. In our detailed calculations for more than 100 rolls, this was 2.0gsm.

Single Position Machine Direction Analysis

As indicated above, single position MD profile was noted for 200 samples. These samples were taken after a machine direction spacing of 2M, i.e., the samples were spaced 2.25M center to center.

Sample Spacing: 2.25m
Number of samples: 200
Length of Paper Tested:
450m (=200*2.25m)
Machine Speed: 230mpm
Net Sampling Duration:
2min. (=450/230)

These values were plotted against time (sample no.). A moving averaged trend line averaging last three values was also plotted. The plot is given in figure-1.

As indicated from the plot, we may observe that-

1. The plot may be considered as consisting of three different segments, each one having fairly stable (for the time being) basis weight.
2. There is a decrease in average basis weight by approx. 6gsm. This is against the information provided by the plant personnel that no change in basis weight

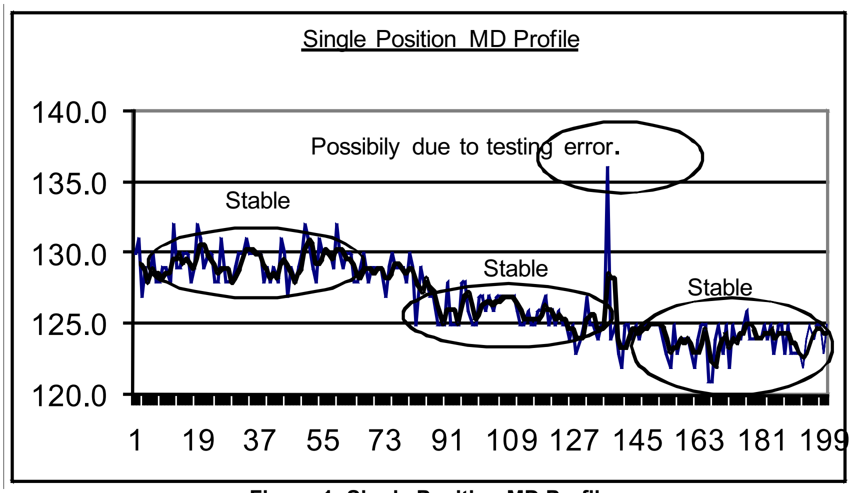

Figure-1: Single Position MD Profile

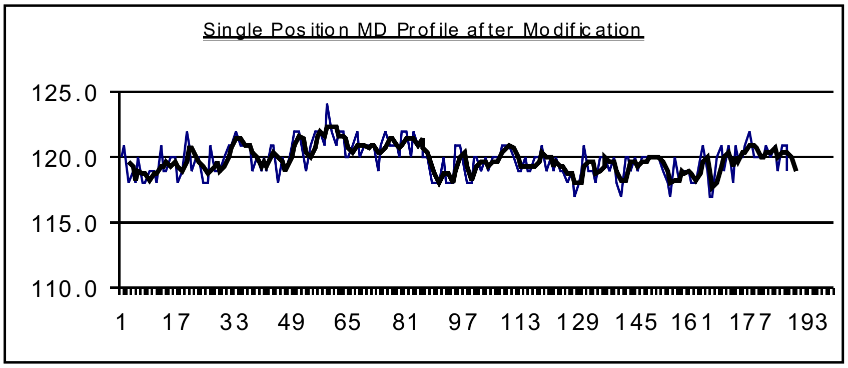

Figure-2: Single Position MD Profile after Modifications

valve opening or the head etc. was made during production of the roll being considered.

3. Between first two zones, there is a sudden decrease in GSM.
4. It can be seen that after every 7-8 data points, there exists a peak. Considering a 2M difference between the samples, the peak-to-peak spacing comes out to be 16M approx. For a machine speed of 230mpm, this matches to a pulse having (=230/16) 14-15 rpm frequency. As indicated above, the same could be due to holey roll no. 1 of the head box.

Actions Taken

The above data suggests that there could be pulsations from different sources including holey roll, pressure screen, improperly designed approach flow piping etc. To begin with, holey roll no. 1 as indicated above was taken out and checked. It was straight and not bent as estimated earlier. So it was mounted again. But, single position MD profiling did not improve at all. So, during the next shut, a dial gauge was mounted to check the ovality of the holey roll in position. A wobbling rotation was confirmed by 1.8mm over its circumference. Since the roll had already been checked, the bearings were replaced considering it as a source of the problem. The dial gauge testing was satisfactory this time and only a minute 0.35mm wobbling was observed. Later, it was observed that the earlier bearings had many scorings on their outer race, which could have been a reason for the wobbling of the roll.

As further improvement in the holey roll alignment was not immediately possible, the machine was started and a satisfactory improvement in single position MD profiling was observed. Here, it is also interesting to note that the average unstability was higher at the centre i.e. at position 3-7 of the profile indicating the possibility of non-linearity in holey roll.

Next, possibility of pressure screen and fan pump was analyzed. The pressure screen speed is 450 rpm, the pulses generated from it can be of either 7.5 Hz or 15 Hz (i.e. 450x1/60 = 7.5Hz, for one impeller blade) only. For a machine running at 230mpm speed, this would result in basis weight pulsations of 0.5M and 0.25M respectively. Checking a number of consequent samples in the machine direction, revealed that there are no variations in basis weight at this scale. Similarly, possibility of pulsations from fan pump is also ruled out.

The next step was analyzing other variations which occur at much lower frequencies, such as once in every one or two minutes or so. For the same, the speed of fan pump and secondary centricleaner pump was checked by digital RPM meter. For the same, a non contact pnp type proximity sensor was mounted on the pump shaft and adjusted to register a pulse whenever the shaft key comes in close proximity of the sensor. The signal was fed to digital rpm meter. There was a difference of ±20rpm over the average value. This difference was being caused due to input voltage and frequency. The mill had installed a servo voltage stabilizer for the whole plant load, but still there were variations to the tune of ±5 to 7 volts. Furthermore, the frequency varied from 48.6Hz to 49.7Hz in most of the cases. But sometimes, it went up to 50.2Hz also. This resulted in approximately 2% increase or decrease in pump speed.

The mill also supported the findings by informing that in case of power failure for long time, whenever the machine is run with power supplied by DG sets, the GSM variation is much lower. So, VFDs were installed for fan pump and secondary centricleaner pump. Since stock was being taken through SR Box, there was no need to install a VFD on machine chest pump. The pipeline vibrations also suggested the possibility of air entrapment, for which a water hose pipe was put near pump gland, so that air cannot enter the system.

Results

After all these activities, drastic improvement in basis weight stability was observed. The figure-2 on th left illustrates the results obtained for 120gsm running on machine.

In addition to single position profile stabilization, following benefits were observed-

1. Much improved basis weight and a significant reduction in basis weight variation in machine and cross direction.
2. For 32 rolls profile, average in 120 gsm paper varied between 117.5 to 124 gsm. (Earlier, it varied between 114 to 128 gsm.)
3. Profile unstability reduced from 2.0gsm earlier to 1.2gsm only.
4. Installation of VFDs on fan pump and secondary centricleaner pumps resulted in reduction in drive power required. The payback period for these drives after load reduction was observed to be nearly 15 months.
5. Significant improvement in machine runnability was observed. Joints reduced from 25-30 per day to 12-15 per day. The production has also improved by 1.0-1.5T per day.

Future Scope

For further improvement in basis weight stability, following work is desirable-

1. Replacement of holey rolls, and their bearing housings.
2. Conversion of open type centricleaner system to closed centricleaners.
3. During shut, fan pump and secondary centricleaner pumps should be checked for gland leakage, and if any, corrective action to be taken.

CONCLUSION

It must be noted that basis weight can be controlled properly if and only if it does not change abruptly within a few seconds every now and then. Repeated testing of single profile MD variation and correcting the problems related can be very useful in achieving a good basis weight control. It is also recommended to first have a single position one minute profile analysis in case having problem related to basis weight variations.